Time of Flight Magnetic Resonance Angiography of the Canine Brain at 3T and at 7T - A Quantitative Comparison

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Introduction

7T ToF-MRA has proven to depict the major intracranial arteries in humans with a quality comparable or better than 3T or 1.5T magnets [1]. Ultrahigh field ToF-MRA has also allowed for the visualization of a larger number of the small intracranial arteries that were either not visualized or seen less clearly with lower field strength magnets [2]. The purpose of this study was to evaluate the ability of 2D ToF-MRA to depict cerebral arteries in the canine brain and to compare the results obtained from a high field magnet (3T) with an ultrahigh field magnet (7T). We hypothesized that ToF-MRA at 7T would depict the vasculature of the canine brain in more detail and with higher quality images than at 3T.

Material and Methods

2D ToF-MRA of the intracranial vasculature was obtained for each dog using a 3T and 7T MRI scanner (Achieva, Philips Healthcare). 3T ToF-MRA images were acquired using an 8-channel receive-only phased array extremity coil designed for the human knee (Philips Healthcare). 7T ToF-MRA studies were acquired with a transmit-receive quadrature human extremity coil (Philips Healthcare). A multi-slice 2D fast field echo (FFE) with a repetition time (TR) of 16 ms was used for both scanners. An echo time (TE) of 7.5 ms and 5.5 ms was used to obtain images at 3T and 7T, respectively. For both scanners, a flip angle of 60 degrees was used and 80 slices with a 1 mm slice thickness were obtained. The geometry parameters were the same for 3T and 7T including a field-of-view (FOV)=120x120mm^2, acquisition matrix=240 x 240 with a resulting 0.5x0.5x1.0mm^3 voxel size using a single excitation (NEX=1). The total acquisition time was 5:21 minutes for 3T MRA-ToF and 5:13 minutes for 7T ToF-MRA. Quantitative assessment of the images was obtained by documenting the visibility of major arteries comprising the cerebral arterial circle and their branches, and recording the number of vessels visualized on the most dorsal 1/3 aspect of the brain. Qualitative assessment was established with blinded, randomized controlled, crossover evaluation of the overall image quality and image artifacts by three independent readers.

Results

Both 3T and 7T allowed visualization of the larger vessels of the cerebral arterial circle. 7T was superior to 3T in depiction of the first- and second-order arterial branches (Table 1). Maximum-intensity projection images (MIP) showed a larger number of vessels at 7T compared to 3T (Figure 1). 2D ToF-MRA of the canine intracranial vasculature at 3T and 7T allows for the depiction of the main intracranial arteries. Compared to 3T, 7T was also able to depict a superior number of the smaller intracranial vessels (Table 2). Overall, image quality and artifacts were similar in both magnets (Figure 2). In a paired two sampled Student's t-test for means, 7T had a significantly higher number of small vessel visualized ($p < 0.01$).

Table 1 Depiction of major intracranial arteries on TOF-MRA in 5 clinically normal dogs at 3T and 7T.

	3T	*7T*
Rostral cerebral arteries	5/5	5/5
First order branches	0/5	4/5
Internal carotid arteries	5/5	5/5
Middle cerebral arteries	5/5	5/5
First order branches	3/5	5/5
Second order branches	2/5	5/5
Caudal Communicating arteries	5/5	5/5
Caudal cerebral arteries	5/5	5/5
Rostral cerebellar arteries	5/5	5/5
Basilar arteries	5/5	5/5
First order branches	0/5	3/5

Table 2 Number of vessels counted in the most dorsal 1/3 aspect of the brain of 5 clinically normal dogs using TOF-MRA at 3T and 7T.

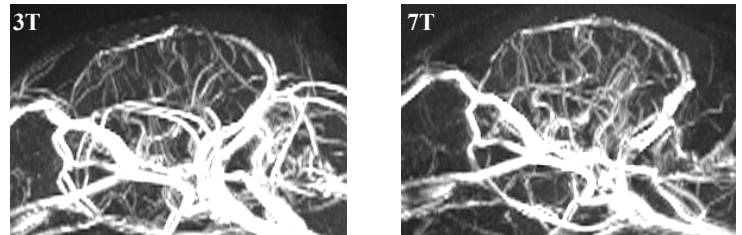| dog	1	2	3	4	5	*mean*	*total*
3T	33	37	37	29	27	32.6	163
7T	36	41	46	32	36	38.2	191

Figure 1 3T (left) and 7T (right) maximum-intensity projection (MIP) of the canine intracranial vasculature. 7T MIP shows intracranially a larger number of vessels compared to 3T MIP.
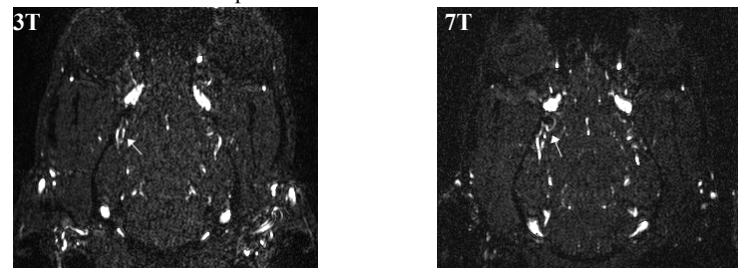

Figure 2 3T (left) and 7T (right) two-dimensional TOF-MRA images from the same dog showing first-order branches arising from the middle cerebral arteries (arrows). 7T can visualize the branches more clearly than 3T.

Conclusion

7T ToF-MRA provides a better delineation of small vessels in the canine brain than 3T ToF-MRA. This suggests that studies of vascular diseases in canines could be improved by imaging at ultra high magnetic fields.

References

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